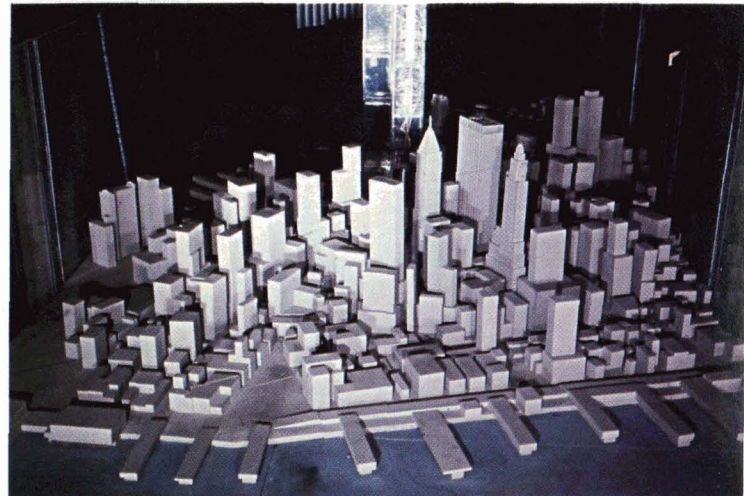


WIND ENGINEERING

Strong winds can cause a lot of problems for buildings, particularly tall buildings—structural damage, glass breakage, excessive sway or inefficient performance of heating, cooling and ventilating systems, to mention just a few of many possible difficulties. Architects can design a building to minimize adverse wind effects and take advantage of beneficial wind motion, if they have detailed information on airflows around the projected structure and neighboring buildings. Such information is provided by wind engineering, a rapidly developing discipline that involves testing models of building designs in wind tunnel facilities that simulate winds, temperatures, pressures and other variables.

Architectural wind engineering was first tried 90 years ago but it did not reach maturity until the mid-1960s, when New York City's World Trade Center (upper right) was in planning status. Project engineers were concerned about wind effect on the 1,350-foot towers, so they consulted several wind engineering experts, among them Dr. Jack E. Cermak, director of the Fluid Dynamics and Diffusion Laboratory at Colorado State University (CSU), Fort Collins, Colorado. A two-year study by Cermak and his design team resulted in important design changes; the group's wind tunnel modeling of the World Trade Center and adjacent structures is shown at right.

Cermak, a 20-year veteran, is one of the leading practitioners of the wind engineering art and the CSU facilities—with four wind tunnels—are among the most comprehensive available. Cermak developed the first wind tunnel to simulate the changing temperatures, directions and velocities of natural winds—as opposed to uniform airflow techniques employed by others. In this work, Cermak benefited from NASA technology related to what is known as the atmospheric boundary layer (ABL), the winds from ground level up to about 2,000 feet. He developed a method of simulating the ABL in a wind tunnel—in order to physically model airflows that cannot be modeled numerically—and sought a method of validating his technique,



specifically a means of comparing the simulation with actual atmospheric flows. He found it in technical literature describing the results of two NASA studies—one by NASA Headquarters and one by Marshall Space Flight Center—analyzing wind flows around a 500-foot meteorological tower at Kennedy Space Center. Collectively, these studies provided an exhaustive analysis of the boundary layer wind and gave Cermak the comparative data he needed for increased confidence in the accuracy of his modeling technique.

In wind studies, the architect supplies the wind engineer design details of the projected building, along with the heights and shapes of existing buildings within a 2,000-foot radius and a topographic map of the site's terrain. From this information, the wind engineering group first constructs solid scale models of the adjacent buildings that will influence wind effect on the new building. Then they build a hollow model of the planned structure, drill several hundred tiny holes in its surface, and connect the holes by tubing to strain gauge pressure transducers. An example is shown at left, where Jack Cermak is preparing for a test run on a model of the Republic Bank Center in Houston, Texas. The whole area model is on a turntable whose rotation allows simulation of changes in wind direction. In operation, the wind tunnel creates various wind speeds and temperatures, the resulting fluctuating pressures are measured by the ultrasensitive strain gauges and the measurements are reported to a computer, which makes the necessary calculations and supplies a complete pressure distribution analysis of the building's surfaces under varying conditions.





U.S. Steel Realty Development Division

Cermak and his CSU group have conducted hundreds of wind studies, most of them on new building designs. The upper left photo shows three Pittsburgh, Pennsylvania buildings (arrows) on which the group worked, from left, the One Oxford Center building, Pittsburgh Plate Glass headquarters and One Mellon Bank Center; at upper right is the area model of the latter. Wind analyses are made for such other purposes as siting wind energy systems, modeling air pollution dispersion, controlling desert sand and simulating wind effect on Space Shuttle launches. Shown at right is a model of Children's Hospital, Washington, D.C. used in an air quality study designed to reduce entry of polluted air. Below, a technician is preparing a model of a large solar energy farm at Barstow, California for a study of wind effect on the solar reflectors.

